

AD-A172 422

HIGH AND LOW ENERGY PARTICLE BEAMS INTERACTIONS WITH
SOLIDS(U) PENNSYLVANIA STATE UNIV UNIVERSITY PARK DEPT
OF CHEMISTRY N WINOGRAD 1986 N00014-83-K-0032

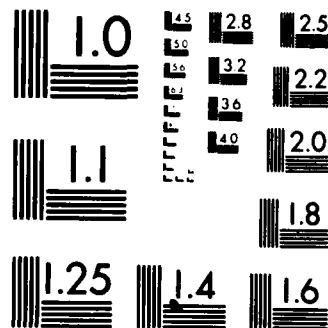
1/1

UNCLASSIFIED

F/G 20/12

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

AD-A172 422

12

OFFICE OF NAVAL RESEARCH

FINAL REPORT

for

"High and Low Energy Particle Beams Interactions with Solids"

Contract N00014-83-K-0052

Task No. NR SRO-152

Nicholas Winograd
Department of Chemistry
152 Davey Laboratory
The Pennsylvania State University
University Park, Pennsylvania 16802

DTIC FILE COPY

DTIC
ELECTE
OCT 1 1986
A

This document has been approved
for public release and sale; its
distribution is unlimited.

86 9 2 069

-1.5

The major goal of our research has been to establish a center for the preparation and surface characterization of advanced materials related to the construction of high speed electronic devices. The focal point of the experimental side of our center has been a molecular beam epitaxial (MBE) growth facility directly attached to a sophisticated surface analysis system. The growth facility has been initially set-up to study the chemical aspects of interface formation during the fabrication of multi-layer systems. The analysis chamber incorporates a number of novel approaches to characterizing the chemistry of these interfaces with unprecedented detail. These include LEED, XPS, angle-resolved SIMS and He atom diffraction. On the theoretical side, our goal has been to establish extensive computational hardware and software for the modeling of the interaction of energetic particles with solids. This project has involved the development of interaction potentials which accurately predict forces between atoms in materials with directional bonding such as GaAs and Si.

At the conclusion of our project, we have been able to accomplish most of the above goals. The MBE facility is now operational and we are growing GaAs films of high quality. Both the theoretical program and advances in surface characterization techniques have proceeded rapidly as evidenced by the numerous technical reports. We have just begun experiments aimed to characterizing the formation of interfaces and Schottky barriers. In a recent study, for example, we have observed surface reconstructions on the As stabilized GaAs(001) surface during deposition of Al. These reconstructions suggest that the Al initially forms two dimensional

clusters along preferred azimuthal directions. Such unusual interface states will be of interest to probe further with our apparatus as the full power of the surface analytical chamber is brought on-line.

The specific research accomplishments are summarized in the list of noted technical reports.



Accession For	
Date	
By	
Dist	
A-1	
Codes	Special

Title of Project

"High and Low Energy Particle Beams Interactions with Solids"

NR-Number

NR SRO-152

Contract No.

NOO014-83-K-0052

Principle Investigator

Nicholas Winograd - (814) 863-0001

Co-Investigators

Barbara Garrison - (814) 863-2103

D. E. Harrison, Jr. - (408) 646-2877

Ming Yu - (914) 945-2564

Dan Frankl - (814) 865-7382

Institution

The Pennsylvania State University

Funding History

January 1, 1983 to December 31, 1983 - \$378,550

January 1, 1984 to December 31, 1984 - \$370,370

January 1, 1985 to December 31, 1985 - \$399,520

Telephone No.

(814) 863-0001

Graduate Students & Postdoctorals Associated with Contract

Rik Blumenthal, Grad Student Alan Schick, Postdoc

Susan Donner, Grad Student Joythia Singh, Postdoc

Joseph Herman, Grad Student Raj Trehan, Postdoc

Brad Weaver, Grad Student Klaus Mann, Postdoc

Mohamed El-Maazawi, Grad Student

Dave Hrubowchak, Grad Student

Mark Kaminsky, Grad Student

Che-Chen Chang, Grad Student

Thesis

Lisa A. DeLouise, Ph.D. Thesis, entitled, "A Multitechnique Characterization of the Reaction of Small Gaseous Molecules on Rhodium Single Crystal Surfaces" 1984.

Roger J. Bleiler, Ph.D. Thesis, entitled, "An Angle-Resolved Secondary Ion Mass Spectrometry Investigation of Adsorbate Structure on Single Crystal Metal Surfaces" 1984.

Fred M. Kimock, Ph.D. Thesis, entitled, "Solids Analysis Using Energetic Ion Bombardment and Multiphoton Resonance Ionization" 1985.

Mark Kaminsky, Ph.D. Thesis, entitled, "Investigation of the Reaction Intermediates and Catalyst Composition that are Relevant for CO Hydrogenation" 1985.

Publications during entire granting period

Velocity Dependence of Azimuthal Anisotropies in Ion Scattering from Rhodium{111}, C.-C. Chang, L. A. DeLouise, N. Winograd, and B. J. Garrison, *Surface Science*, 154, 22-34 (1985). Partial support from NSF.

Ejection of Atoms from Rare-Gas Solid by Low Energy Cascades, B. J. Garrison and R. E. Johnson, *Surface Science* 148, 388 (1984). Partial support from NSF.

Theoretical Studies of Fast He Atom Scattering from a W{100} Surface, C.-C. Chang, B. J. Garrison and T. A. Delchar, *Surface Science*, 155, 327-340 (1985). Partial support from NSF.

Vertical Channeling of Pyridine Molecules Ejected in Ion Bombardment Experiments, D. W. Moon, N. Winograd, and B. J. Garrison, *Chemical Physics Letters* 114, 237 (1985).

Laser Ablation of Organic Polymers: Microscopic Models for Photochemical and Thermal Processes, B. J. Garrison and R. Srinivasan, *Journal of Applied Physics* 57, 2909 (1985). Partial support from NSF.

Theory of Non-adiabatic Gas-Surface Reactions, J. A. Olson and B. J. Garrison, *Journal of Chemical Physics*, 83, 1392-1403 (1985).

Ablative Decomposition of Polymers, B. J. Garrison and R. Srinivasan, *Journal of Vacuum Science and Technology*, A3, 746-748 (1985). Partial support from NSF.

Cluster Desorbed, Ejected and Ablated from Solid Surfaces B. J. Garrison, Symposium of Atomic and Surface Physics, 273 (1985). Partial support from NSF.

Theory of Near-Resonant Charge-Exchange in Gas-Surface Reactions, J. A. Olson and B. J. Garrison, *Nuclear Instruments and Methods in Physics Res.*, B14, 414 (1986). Supported by Navy.

Particle Bombardment as Viewed by Molecular Dynamics, B. J. Garrison, ACS Symposium Series, 291, *J. Amer. Chem. Soc.*, Washington, D.C., 43-55 (1985).

The Dilemma in Defining the Velocity and Angle Dependence of the Probability of Electronic Excitation near a Surface, B. J. Garrison, *Surface Science Letters*, 167, L225 (1986). Partial support from NSF.

Mechanisms of Organic Molecule Ejection in SIMS and FABMS, D. W. Brenner and B. J. Garrison, Springer Series in *Chemical Physics*, Vo. 44, p. 462, Springer-Verlag, Berlin (1986),

A Molecular Dynamics Simulation of the Time Dependence of Surface Damage Production in Ion Irradiated Metal Targets, R.P. Webb and D. E. Harrison, Jr., *Vacuum*, 34, 847 (1984). Partial NSF support.

Micro Phase Transitions in Molecular Dynamics Simulations of Low Energy Ion Irradiation of Metals, R. P. Webb, D. E. Harrison, Jr., and K. M. Barfoot, *Nucl. Instrum. Method B*, 7/8, 143 (1985). Partial NSF support.

Influence of Electronic Energy Losses on Atom Ejection Processes, M. M. Jakas and D. E. Harrison, Jr., *Phys. Rev. B15*, 30, 3573 (1985).

Computer Studies of the Reflection of 30keV N_2^+ Ions from (010) Cu Surface, M. M. Jakas and D. E. Harrison, Jr., *Surface Science*, 149, 500 (1985).

A Summary of the Theory of Preferential Sputtering of Alloys, R. Kelly and D. E. Harrison, Jr., *Mat. Sci. and Eng.*, 69, 449 (1985). (While visiting scientist at IBM/Watson Center).

Inelastic Energy Losses in Cascades and Atom Ejection, D. E. Harrison, Jr. and Mario M. Jakas, *Nucl. Instrum. Methods*, B15, 25 (1986).

Simulation of the Atomic Collision Cascade, D. E. Harrison, Jr. and Mario M. Jakas, *Radiat. Effects*, 91, 263 (1986).

The Dependence of Atom Ejection on Electronic Energy Loss, Mario M. Jakas and D. E. Harrison, Jr., *Phys. Rev.* 32B1, 2752 (1985)

Many-Body Effects in Atomic Collision Cascades, Mario M. Jakas and D. E. Harrison, Jr., *Phys. Rev. Letters*, 55(17), 1782 (1985).

A Comparison Between Multiple Interaction Computer Simulations and the Linear Theory of Sputtering, Mario M. Jakas and D. E. Harrison, Jr., *Nucl. Instrum. Method*, B14, 535 (1986).

Phosphorus-Doped Polycrystalline Silicon via LPCVD II, Surface Interaction of Silane/Phosphine/Silicon System, B. S. Meyerson and M. L. Yu, *J. Electrochem. Soc.* 131, 2366 (1984). Partial IBM support.

The Origin of Oxidation Induced Enhancement of Si^+ Sputter Yield in SIMS, M. L. Yu, J. Clabes, and D. J. Vitkavage, *J. Vac. Sci. Technol.* A3(3), 1316 (1985). Partial IBM support.

Comparison Between the Adsorption of PH_3 and B_2H_6 on Si Surfaces as Related to the CVD of Si, M. L. Yu, D. J. Vitkavage and B. S. Meyerson, *J. Vac. Sci. Technol.* A3(3), 861 (1985). Partially supported by IBM.

Chemical Enhancement Effects in SIMS Analysis, M. L. Yu, *Nucl. Instrum. Methods in Physics Research* B15, 151 (1985). Partially supported by IBM.

Doping Reaction of PH_3 and B_2H_6 with Si(100), M. L. Yu, D. J. Vitkavage and B. S. Meyerson, *J. Appl. Phys.* 59 (1986). Partially supported by IBM.

Mechanisms of Atomic Ion Emission During Sputtering, M. L. Yu and N. D. Lang, *Nucl. Instrum. Methods in Physics Research B14* (1986) 403. Partially supported by IBM.

Origin of the Chemical Enhancement of Positive Secondary Ion Yield in SIMS, K. Mann and M. L. Yu, Proceeding of the 5th International Conference on Secondary Ion Mass Spectrometry, Springer Series in *Chemical Physics* 44 (1986) 26. Partially supported by IBM.

Solid Analysis Using Energetic Ion Bombardment and Multiphoton Resonance Ionization, F. M. Kimock, J. P. Baxter, D. L. Pappas, P. H. Kobrin and N. Winograd, *Anal. Chem.*, 56, (1984) 2782. Partial support by NSF and AFOSR.

Reduction of Nitric Oxide on the Carbon Pretreated Rh{331} Single Crystal Surface; Evidence for Molecular CN⁻ Formation, L. A. DeLouise and N. Winograd, *Surface Sci.*, 154, (1985) 79. Partial support by NSF and AFOSR.

Adsorption and Desorption of NO From Rh{111} and Rh{331} Surfaces, L. A. DeLouise and N. Winograd, *Surface Sci.*, 159, (1985) 199. Partial support by NSF and AFOSR.

Angle-Resolved Secondary Ion Mass Spectrometry, in *Chemistry and Physics of Solid Surfaces V*, N. Winograd, Springer Series in *Chemical Physics*, 35, 403 (1983).

Examination of Excited State Populations in Sputtering Using Multiphoton Resonance Ionization, F. M. Kimock, J. P. Baxter, D. L. Pappas, P. H. Kobrin and N. Winograd *Analytical Spectroscopy 26th ORNL Conference on Analytical Chemistry in Energy Technology*, Knoxville, TN, 1983, page 179.

Thin Film Electrodes, N. Winograd, *Laboratory Techniques in Electroanalytical Chemistry*, P. T. Kissinger, Ed., Marcell-Dekker, New York, 1984, page 321.

ESCA and Electrode Surface Chemistry, J. S. Hammond and N. Winograd, *Comprehensive Treatise on Electrochemistry*, Vol. 8, Chapter 8, R. E. White, J. O'M. Bockris, B. E. Conway and E. Yeager, Ed., Plenum Publishers, New York, 1984, page 445.

A SIMS and Classical Dynamics Study of the Chemisorption of CO on Ni{7 9 11}, K. E. Foley, N. Winograd, B. J. Garrison and D. E. Harrison, Jr., *J. Chem. Phys.* 80, 5254 (1984).

Detection of Sputtered Neutrals by Multiphoton Resonance Ionization, F. M. Kimock, J. P. Baxter, D. L. Pappas, P. H. Kobrin, and N. Winograd, *Secondary Ion Mass Spectrometry - SIMS IV*, Springer Series in *Chemical Physics* 36, 62 (1984).

Ion Beam Studies of Surfaces by Multiphoton Resonance Ionization of Sputtered Neutrals, N. Winograd, Symposium on Atomic and Surface Physics (SASP), Maria Alm, Austria, 1984, page 268.

Characterization of CO Binding Sites on Rh{111} and Rh{331} Surfaces by XPS and LEED: Comparison to EELS Results, L. A. DeLouise, E. White and N. Winograd, *Surface Sci.* 147, 252 (1984).

Ion Beam Studies of Surfaces by Multiphoton Resonance Ionization of sputtered neutrals, N. Winograd, Resonance Ionization Spectroscopy, Institute of Physics Conference Series Number 71, 1984, page 161.

Velocity Dependence of Azimuthal Anisotropies in Ion Scattering from Rhodium{111}", C. C. Chang, L. A. DeLouise, N. Winograd and B. J. Garrison, *Surface Sci.* 154, 22 (1985).

Vertical Channeling of Pyridine Molecules Ejected in Ion Bombardment Experiments, D. W. Moon, N. Winograd and B. J. Garrison, *Chem. Phys. Lett.* 114, 237 (1985).

Angle-resolved Secondary Ion Mass Spectrometry, N. Winograd, in Desorption Mass Spectrometry: Are SIMS and FAB the same?, ACS Symposium Series 291, P. A. Lyon, Ed., Washington D.C., 1985, page 83.

Fundamental Aspects of Energetic Particle/Solid Interactions, N. Winograd, *Scanning Electron Microscopy III* 1985, 919 (1985).

Ion Beam Techniques, N. Winograd, New Directions in Chemical Analysis, B. L. Shapiro, Ed., Texas A&M University Press, College Station, Texas, 1985, page 263.

Matrix Effects on the Electronic Partitioning of Iron Atoms Desorbed from Surfaces by Energetic Ion Bombardment, F. M. Kimock, D. L. Pappas, and N. Winograd, *Anal. Chem.* 57, 2669 (1985).

Technical reports during entire granting period

The above listed reprints were each sent through as a technical report.

END

10-86

DTIC